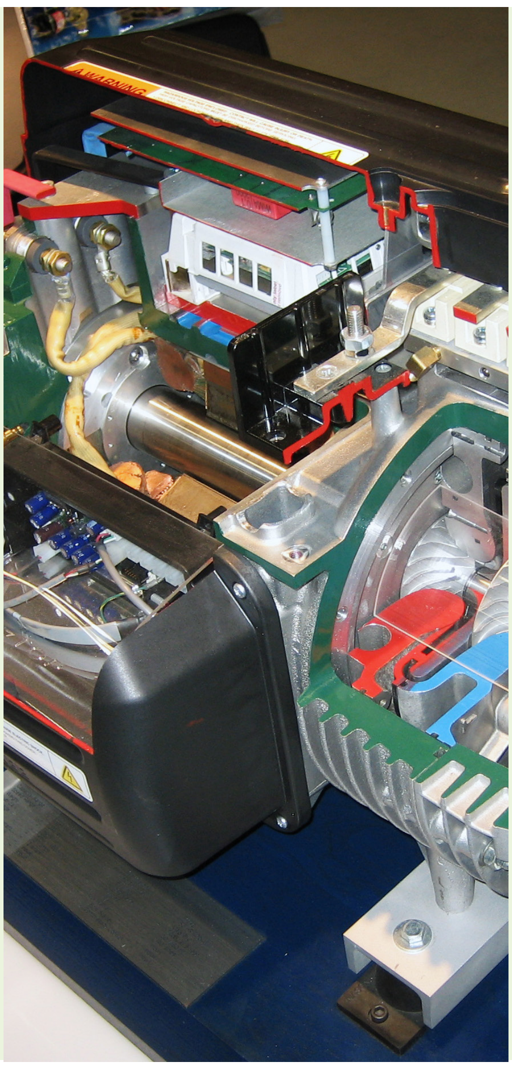
GSA Public Buildings Service

GSA

FINDINGS 09, OCTOBER 2013

MAGNETIC LEVITATION CHILLER COMPRESSOR



Magnetic Levitation Chiller Compressor Reduces Space Cooling Energy Consumption

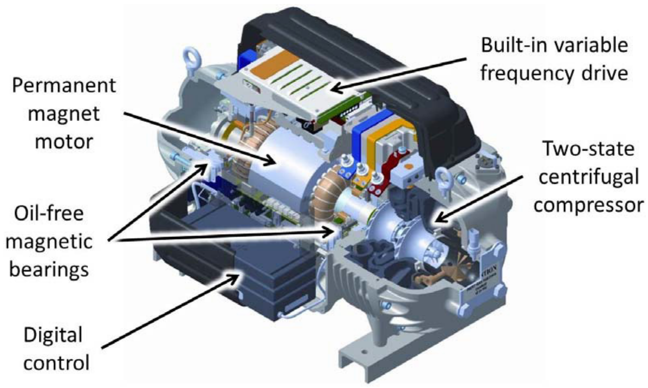
In the U.S., space cooling accounts for 9.6% of energy consumption in office buildings. Because space cooling is primarily driven by electricity—a higher cost energy source—it can account for an even greater percentage of a facility's annual energy bill.[1] Chillers, used frequently in larger facilities, provide cooling in 31% of office building floor space within U.S. commercial buildings.[2]

GSA's Green Proving Ground (GPG) recently evaluated the effect of new, more efficient chiller compressor technology on energy cost and consumption by assessing a magnetic levitation ("maglev") chiller compressor at the George Howard, Jr. Federal Building and U.S. Courthouse in Pine Bluff, Arkansas. This new chiller compressor technology offers quieter, more efficient cooling at lower partial loads than rotary-screw chillers, due to its ability to reduce friction, operate at variable speeds, and integrate with diagnostics and monitoring systems. GPG's initial findings recommend replacing end-of-life rotary-screw chillers with maglev chiller compressors.

GPG Green Proving Ground Program

The Green Proving Ground program leverages GSA's real estate portfolio to evaluate innovative sustainable building technologies. The program aims to drive innovation in environmental performance in federal buildings and help lead market transformation through deployment of new technologies.

INTRODUCTION



Magnetic Levitation Chiller Compressor
Image courtesy of Danfoss Turbocor Compressors, Inc., used with permission

"We realized significant savings when comparing the new compressor technology with the rotary screw compressor."

—Mark Trimarchi, P.E., C.E.M.
Regional Energy Engineer
U.S. General Services Administration
Greater Southwest Region
Fort Worth, TX

PERFORMANCE SPECIFICATIONS
Energy Efficiency

FEMP GUIDELINES (IPLV[3])

Rotary Screw	**0.51**
Variable Speed Maglev	**0.33 - 0.37**

MEASURED (NPLV[4])

Rotary Screw	**0.704**
Variable Speed Maglev	**0.519**

What We Did

EXPERTS MONITORED PERFORMANCE OF OLD AND NEW CHILLERS OVER A SIX-MONTH PERIOD

In February 2012, GSA replaced one of the two 150-ton rotary-screw chillers at the George Howard, Jr. Federal Building—a four-story, 108,000 square foot courthouse and office building—with a 150-ton chiller with two magnetic levitation compressors. The Pacific Northwest National Laboratory (PNNL) monitored the performance of both the new chiller and the remaining original chiller for a six-month period from March through September to determine their cooling load profiles and project a weather-normalized assessment of energy savings offered by the new technology.

What We Measured

DATA SYSTEM RECORDED CHILLER EFFICIENCY AND UTILITY USAGE

PNNL employed an independent data acquisition system (DAS) that scanned meters and sensors every second to generate a comprehensive dataset of chiller performance. Chiller efficiency was measured with the coefficient of performance (COP) — the ratio of cooling energy provided to the amount of energy consumed. The amount of electricity demanded by each chiller was also measured and recorded. Weather data was gathered and normalized to project the performance of the chillers over a typical meteorological year (TMY).

FINDINGS

HIGH EFFICIENCY AT LOW COOLING LOADS The maglev chiller compressor achieved energy savings of 42%, due in large part to the regularity with which chillers operate at partial load. The variable speed drive allows the chiller to perform at higher efficiency at lower and partial cooling loads, compared with standard chillers with less flexibility in operational speed and power. During a testing period with above-average outside temperatures, the operating chiller spent 80% of the time operating at a load-factor below 50%. As cooling load factors decrease, the efficiency of magnetic levitation compressors becomes more pronounced.

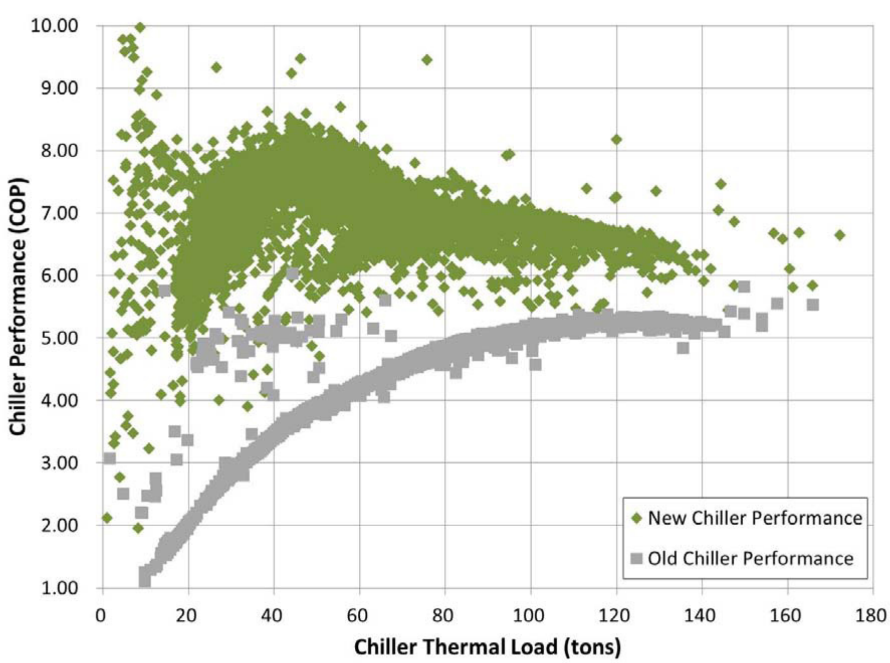
REDUCED LONG- AND SHORT-TERM MAINTENANCE The rotating shaft of the new compressor is levitated with magnetic bearings, thus eliminating the metal-on-metal contact of conventional bearings. In addition to increasing efficiency, the elimination of friction removes the need for lubricating oil and the ancillary components required to support the oil system. The new compressor also features a “soft-start” capability to reduce start-up stresses that contribute to long-term maintenance issues.

SMALLER SIZE AND QUIETER PERFORMANCE Though the physical footprint of the centrifugal chiller remains similar to that of conventional chillers, maglev compressors are smaller and lighter than other compressor types of similar capacity. The new compressors also run more quietly than other chiller options, allowing chiller plants to be located closer to occupant spaces.

END-OF-LIFE REPLACEMENT FOR ROTARY-SCREW COMPRESSORS GSA recommends targeted deployment of the magnetic levitation chiller compressor as an end-of-life replacement for chillers with rotary-screw compressors.

Efficiency of New Chiller Increases as Load is Reduced

New chiller efficiency is highest between 40 to 50 tons (27 to 33% of nominal full load)
Old chiller efficiency continuously decreases as chiller load is reduced



CONCLUSIONS

These Findings are based on the report, "Variable-speed Oil-free Centrifugal Chiller with Magnetic Bearings Assessment: George Howard, Jr. Federal Building and U.S. Courthouse, Pine Bluff, Arkansas" which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact Green Proving Ground gpg@gsa.gov

What We Concluded

MAGNETIC LEVITATION CHILLER COMPRESSORS SHOW PROMISE FOR ENERGY SAVINGS

The test case at the George Howard, Jr. Federal Building resulted in an annualized $9,097 reduction in energy costs, or a 4.7-year payback period, after normalizing for payment structure and per-unit utility costs, supporting the assertion that maglev chiller compressors can bring considerable energy savings compared to traditional rotary-screw compressors. Similar studies conducted by the US Navy, in which only the compressor was replaced and not the entire chiller, delivered comparable energy savings and even lower simple payback. Because this technology is still young, it can be difficult to determine a reliable installation cost. Purchase and installation costs have ranged from $744/ton to $2,568/ton at GSA installations and other test sites, due to numerous variances. Still, such costs are expected to decrease as the new compressor becomes more readily available. Given these uncertainties, GSA recommends targeted deployment of this technology as an end-of-life replacement for chillers with rotary-screw compressors.

Lessons Learned

CONDUCT TESTING ON A LARGER SCALE, REASSESS THERMAL LOAD, USE DIAGNOSTIC SYSTEM

The test case supported claims that maglev chiller compressors operate most efficiently at lower partial loads, but because larger chillers (i.e. with capacities between 500 and 1,000 tons) account for a greater percentage of chiller energy within GSA's portfolio, additional testing should be undertaken to evaluate the effectiveness of this technology on a larger scale.

Because chiller plant efficiency is a function of the equipment's partial load factor, it is important to optimize the modularity of the chiller plant (e.g., two chillers at 75% load or three chillers at 50% load) based on the cooling profile of the facility. It is also recommended that the building's thermal load be reassessed during the retrofit design phase to avoid over-sizing the cooling plant.

Water temperature resets for the cooling tower and chilled water supply are highly beneficial to chiller efficiency; the chiller can best be calibrated to meet specific cooling demand loads by maintaining control over the temperature of entering water.

The ability to monitor, diagnose, and optimize chiller performance is best captured through the use of a full dashboard system. In touring multiple GSA installations, it was noted that none of them had fully installed this capability.

Footnotes

[1]EIA (2003b), Commercial Buildings Energy Consumption Survey: Energy End Use Consumption Tables, Table E.1. Major Fuel Consumption (Btu) by End Use for Non Mall Buildings, 2003, U.S. Energy Information Administration, Washington, DC, http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set19/2003pdf/e1 e11.pdf, last accessed 07/05/2012.

[2]EIA (2003a), Commercial Buildings Energy Consumption Survey. Table 8. Types of Heating Equipment Used in Office Buildings, 2003, U.S. Energy Information Administration, Washington, DC, http://www.eia.gov/emeu/cbecs/cbecs2003/officereport/office3.html, last accessed 07/05/2012.

[3]IPLV, integrated part-load value is a seasonal average efficiency measure using kW/ton.

[4]NPLV, non-standard part-load value is not equivalent to IPLV. IPLV is tested according to standard rating conditions which includes controlled condenser water temperatures that are progressively lower for lower partial loads—conditions that did not exist at the demonstration location.